oct 2015

4. A mass of 1 kg of hydrogen occupies a volume of 11.2 m^3 at a pressure and temperature of 1 bar and -3°C respectively.

   Calculate the value of the characteristic gas constant. (7)

july 2013

4. The initial pressure, volume and temperature of a gas are 0.9 bar, 0.8 m^3 and 27°C respectively. During isothermal expansion the pressure is halved.

   Calculate EACH of the following:

   (a) the final volume of the gas; (3)

   (b) the mass of the gas. (3)

   Note: the characteristic gas constant is 0.52 kJ/kgK

july 2017

2. (a) Define Boyle's Law for a perfect gas. (2)

   (b) A hot air balloon contains 1100 litres of a perfect gas at a pressure and temperature of 1.5 bar and 27□C respectively. The temperature of the gas rises to 69□C at constant pressure.
   Calculate EACH of the following:

   (i) the increase in the volume of the balloon in m^3; (3)

   (ii) the mass of gas in the balloon. (3)

   Note: for the gas R = 0.25 kJ/kgK

july 2016

5. (a) Define Charles' Law for a perfect gas. (2)

(b) Air at a pressure and volume of 50 kN/m^2 gauge and 3.25 m^3 respectively is compressed at constant temperature to a gauge pressure of 4 bar.
The atmospheric pressure is 1 bar.

Calculate the final volume. (5)

march 2018

2. A mass of 0.049 kg of a perfect gas is contained in a cylinder at a constant temperature of 47°C. At a pressure of 1 bar the density of the gas is 1.225 kg/m^3.

Calculate EACH of the following:

(a) the density of the gas when the pressure is reduced to 80 kN/m^2; (4)

(b) the characteristic gas constant. (5)

dec 2016

GENERAL ENGINEERING SCIENCE II December 2016

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) Define Boyle's Law for a perfect gas. (2)

(b) A hot air balloon contains 1200 litres of a perfect gas at a pressure and temperature of 1.5 bar and 14°C respectively. The temperature of the gas rises to 62°C at constant pressure.

Calculate EACH of the following:

(i) the increase in the volume of the balloon in m^3; (4)

(ii) the mass of gas in the balloon. (3)

Note: for the gas R = 0.25 kJ/kgK

july 2014

2. The initial pressure, temperature and volume of a mass of gas are 1.012 bar, 19°C and 2.4 litres respectively. The gas expands at constant temperature to a volume of 8.4 litres and then the temperature rises to 68°C at constant pressure.

Calculate EACH of the following:

(a) the final pressure of the gas in kN/m^2; (4)

(b) the final volume of the gas in m^3; (3)

(c) the work done during the constant pressure process. (3)

july 2015

3. The initial pressure, temperature and volume of a mass of gas are 1.3 bar, 13°C and 1.6 litres respectively. The gas expands at constant temperature to a volume of 5.2 litres and then the temperature rises to 57°C at constant pressure.

Calculate EACH of the following:

(a) the final pressure of the gas in kN/m^2; (5)

(b) the final volume of the gas in m^3. (5)

march 2017

2. A perfect gas is cooled at constant pressure. The initial pressure, temperature and volume of the gas are 1.03 bar, 0°C and 0.035 m^3 respectively. During the process the temperature of the gas is reduced to 243 K.
Calculate EACH of the following:

(a) The mass of the gas; (4)

(b) The final volume of the gas. (4)

Note: the Characteristic Gas Constant = 0.259 kJ/kgK dec 2014

GENERAL ENGINEERING SCIENCE II December 2014

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) A perfect gas at a pressure, temperature and volume of 9.9 bar, 327°C and 8 m^3 respectively expands to a pressure and volume of 660 kN/m^2 and 11 m^3 respectively.

Calculate EACH of the following:

(i) the mass of the gas; (4)

(ii) the final temperature. (4)

Note: the characteristic gas constant = 0.3 kJ/kgK

march 2015

3. A perfect gas at a pressure, temperature and volume of 9.75 bar, 477°C and 9 m^3 respectively expands to a pressure and volume of 550 kN/m^2 and 11.7 m^3 respectively.

Calculate EACH of the following:

(a) the mass of the gas; (4)

(b) the final temperature. (4)

Note: the characteristic gas constant = 0.3 kJ/kgK

Ideal Gas Equation

Boyle's law: $V \alpha \frac{1}{P}$ (at constant n and T)

Charles' law: $V \alpha T$ (at constant n and P)

Avogadro's law: $V \alpha n$ (at constant P and T)

$V \alpha \frac{nT}{P}$

$V = \text{constant} \times \frac{nT}{P} = R\frac{nT}{P}$ R is the **gas constant**

$PV = nRT$

PV = nRT

1. P is pressure measured in atmosphere
2. V is volume measured in Liters
3. n is moles of gas present
4. R is a constant that converts the units. Its value is 0.0821 atm.L/mol.K
5. T is temerature measured in Kelvin
6. Simple algebra can be used to solve for any of these values.

$p = \frac{nRT}{V}$ $V = \frac{nRT}{P}$ $n = \frac{PV}{RT}$ $T = \frac{PV}{nR}$ $R = \frac{PV}{nT}$

Pressure Units

	Pascal	Bar	Pounds per square inch	Standard atmosphere	Technical atmosphere
1 Pa	XX	0.00001	0.000145	0.0000099	0.0000102
1 bar	100000	XX	14.5	0.987	1.020
1 psi	6895	0.0689	XX	0.0680	0.0703
1 atm	101330	1.013	14.7	XX	1.033
1 at	98670	0.981	14.2	0.968	XX

$0°C = -273°K$

oct 2015

4. A mass of 1 kg of hydrogen occupies a volume of 11.2 m³ at a pressure and temperature of 1 bar and -3°C respectively.

   Calculate the value of the characteristic gas constant. (7)

$R = x$
$m = 1 \text{ kg}$
$V = 11.2 \text{ m}^3$
$P = 1 \text{ bar}$
$T = -3°$

$PV = nRT$

$P = 1 \text{ bar} \times 100{,}000 = 100{,}000 \text{ Pascals}$

$T = -3°C + 273 = 270° K$

$n = \frac{\text{Mass}}{\text{RAM}} = \frac{1 \text{kg}}{1} = 1$

$PV = nRT$

$100{,}000 \times 11.2 = 1 \times R \times 270$

$\frac{100{,}000 \times 11.2}{270} = R = 4148.148 \text{ J/kgK}$

july 2013

4. The initial pressure, volume and temperature of a gas are 0.9 bar, 0.8 m^3 and 27°C respectively. During isothermal expansion the pressure is halved.

Calculate EACH of the following:

(a) the final volume of the gas; (3)

(b) the mass of the gas. (3)

Note: the characteristic gas constant is 0.52 kJ/kgK 520

$PV = nRt$

$P = 0.9$ bar $\times 100{,}000 = 90{,}000$

$R = 520$ J/kg K

intial	final
$P = 90{,}000$	P 45,000
$V = 0.8$	$V = x$
$m = 1$	m 1
$t = 27°C + 273 =$	$t = 27$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$P_1V_1 = P_2V_2$

$$\frac{90{,}000 \times 0.8}{27} = \frac{45{,}000\, x}{27}$$

$$x = 1.6\ m^3$$

b)

$PV = nRt$

$90{,}000(0.8) = n \times 520 \times 300$

$$n = \frac{90{,}000 \times 0.8}{520 \times 300} = 0.461538\ kg$$

2. (a) Define Boyle's Law for a perfect gas. (2)

(b) A hot air balloon contains 1100 litres of a perfect gas at a pressure and temperature of 1.5 bar and 27□C respectively. The temperature of the gas rises to 69□C at constant pressure.

Calculate EACH of the following:

(i) the increase in the volume of the balloon in m^3; (3)

(ii) the mass of gas in the balloon. (3)

Note: for the gas R = 0.25 kJ/kgK = 250

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$V_1 = 1100L = 1.1\ m^3$

$P_1 = 1.5$ bar $150{,}000$ pa

$T_1 = 27°C + 273 = 300$ k

$V_2 = x$

$P_1 = 1.5$ bar $= 150{,}000$

$T_2 = 69°C = 342$

$$\frac{1.1 \times 150000}{300} = \frac{150{,}000\, x}{342}$$

New vol $x = 1.254\ m^3$

increase $1.254 - 1.1 = 0.154\ m^3$

ii) $PV = mRt$

$150{,}000 \times 1.1 = \text{Mass} \times 250 \times 300$

Mass 2.2 kg

ASCENSION EXÉCUTÉE PAR CHARLES DANS LA PRAIRIE DE NESLES, LE 1er DÉCEMBRE 1783

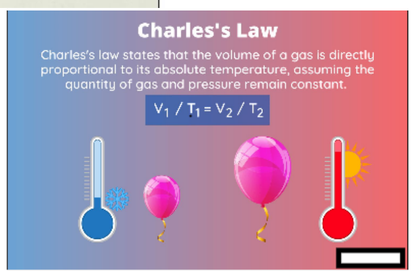
Boyles law,: as pressure increases volume decreases, and vice versa (for a perfect gas, with a constant temp

Pressure $\propto$ vol

july 2016

5. (a) Define Charles' Law for a perfect gas. (2)
(b) Air at a pressure and volume of 50 kN/m² gauge and 3.25 m³ respectively is compressed at constant temperature to a gauge pressure of 4 bar.
The atmospheric pressure is 1 bar.

Calculate the final volume. (5)



4 bar + 1

a) As temp increases volume also increases, and as temp decreases volvume also decreases. Pressurçe is kept the same, aswell as mass of the gas

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$PV = mrt$

$$\frac{V_1 \; P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$V = 3.25$
$P = 50 kN/m^2$
$+ 1 bar$
$= 150,000 \; N/m^2 \; (Pa)$

$T_1 = 1$

$V = x$
$P = 4 \; bar$
$+ 1 \; bar$
$= 500,000 \; Nm^2 \; (Pa)$

$T_2 = 1$

$(3.25 \times 150,000) = x \; (500,000)$

$x = 0.975 \; m^3$

Q5.

a. Charles Law:

For a fixed mass of an ideal gas at a constant pressure, the volume is directly proportional to the temperature measured in kelvin.

$V \propto T$

b. $p_i = 50 \times 10^3 + 1 \times 10^5$, $V_i = 3.25 \; m^3$, $p_f = 4 \times 10^5 + 1 \times 10^5$,

$pV = C \; p_iV_i = p_fV_f$ $V_f = p_iV_i \div p_f$

$V_f = (50 \times 10^3 + 1 \times 10^5) \times 3.25 \div (4 \times 10^5 + 1 \times 10^5) = 0.975 \; m^3$

Final volume is 0.975 m³. ANS.

march 2018

2. A mass of 0.049 kg of a perfect gas is contained in a cylinder at a constant temperature of 47°C. At a pressure of 1 bar the density of the gas is 1.225 kg/m³.

Calculate EACH of the following:

(a) the density of the gas when the pressure is reduced to 80 kN/m²; (4)

(b) the characteristic gas constant. (5)

$PV = mRT$

$m = 0.049$

$t = 47°C + 273 = 320°K$

$P = 1 \text{ bar} = 100{,}000 \; (P_a = N/m^2)$

a)

$P_1 = 100{,}000 \quad P_2 = 80{,}000$

$V_1 = 0.04 \quad V_2 = x$

$T_1 = 320 \quad T_2 = 320$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$100{,}000 \times 0.04 = 80{,}000\,x$

$x = 0.05 \; m^3$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\text{density} = \frac{\text{Mass}}{\text{Vol}} = \frac{1.225 \text{ kg}}{1 \text{ m}^3}$$

$$1.225 = \frac{0.049}{\text{Vol}}$$

$$\text{Vol} = \frac{0.049}{1.225} = 0.04 \; m^3$$

$$\text{density} = \frac{\text{Mass}}{\text{Vol}}$$

$$\text{density} = \frac{0.049}{0.05} = 0.98 \; kg/m^3$$

b) $PV = mRT$

$100{,}000 \times 0.04 = 0.049 \times R \times 320$

$255 \; J/kgK$

dec 2016

GENERAL ENGINEERING SCIENCE II December 2016

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) Define Boyle's Law for a perfect gas. (2)

(b) A hot air balloon contains 1200 litres of a perfect gas at a pressure and temperature of 1.5 bar and 14°C respectively. The temperature of the gas rises to 62°C at constant pressure.

Calculate EACH of the following:

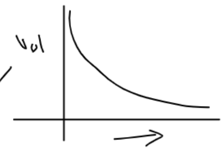
(i) the increase in the volume of the balloon in m³; (4)

(ii) the mass of gas in the balloon. (3)

Note: for the gas R = 0.25 kJ/kgK = 250

$V_1 P_1 = V_2 P_2$ ✓

increasing pressure reduces volume of a perfect gas, given that the tmerperature and mass remain constant ✓



$V = \frac{k}{P}$

$V \propto \frac{1}{P}$ inverse proportional

$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$

b)

$V_1 = 1.2 m^3$

$P_1 = 1.5 bar = 150,000 pa$

$T_1 = 14°C = 287°K$

$V_2 = x = 1.4$

$P_2 = 150,000$

$T_2 = 62°C = 335°K$

$\frac{1.2}{287} = \frac{x}{335}$

increase = $0.2007 m^3$

ii) $Pv = mRt$

$\frac{150,000 \times 1.2}{250 \times 287} = m = 2.5087 kg$

july 2014

2. The initial pressure, temperature and volume of a mass of gas are 1.012 bar, 19°C and 2.4 litres respectively. The gas expands at constant temperature to a volume of 8.4 litres and then the temperature rises to 68°C at constant pressure.

Calculate EACH of the following:

(a) the final pressure of the gas in kN/m²; (4)

(b) the final volume of the gas in m³; (3)

(c) the work done during the constant pressure process. (3)

$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$

$V_1 = 2.4L = 0.0024 m^3$
P_1 1.012 bar = 101,200 Pa
T_1 19°C = 292°K

$V_2 = 0.0084$
$P_2 = 28914$
$T_2 = 292$

$V_3 = y$
$P_3 = 28914$
$T_3 = 341$

$V_1 P_1 = V_2 P_2$

$0.0024 \times 101,200 = 0.0084 x$

$x = 28,914$ Pa

a) $28.9 kN/m^2$

$\frac{V_2 P_2}{T_2} = \frac{V_3 P_3}{T_3}$

$\frac{0.0084}{292} = \frac{y}{341}$

$y = 9.8096 \times 10^{-3} m^3$

Work done = Pressure × change in Vol

$W = P \Delta V$

$W = 28914 (0.0098 - 0.0084) = 40.4796 J$

0.0084
0.0098

$(V_3 - V_2)$

New - old = change

july 2015

3. The initial pressure, temperature and volume of a mass of gas are 1.3 bar, 13°C and 1.6 litres respectively. The gas expands at constant temperature to a volume of 5.2 litres and then the temperature rises to 57°C at constant pressure.

Calculate EACH of the following:

(a) the final pressure of the gas in kN/m^2; (5)

(b) the final volume of the gas in m^3. (5)

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

V_1 1.6 L = 1.6×10^{-3} m^3

P_1 = 1.3 bar = 130,000

T_1 = 13 °C = 286 K

V_2 = 5.2×10^{-3} m^3

P_2 = 40,000

T_2 = 286

V_3 = y

P_3 = 40,000

T_3 = 330

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$1.6 \times 10^{-3} \times 130{,}000 = 5.2 \times 10^{-3} x$$

x = 40,000 Pa

a) P_2 = 40 kN/m^2

$$\frac{V_2 P_2}{T_2} = \frac{V_3 P_3}{T_3}$$

$$\frac{5.2 \times 10^{-3}}{286} = \frac{y}{330}$$

V = 0.006 m^3

march 2017

2. A perfect gas is cooled at constant pressure. The initial pressure, temperature and volume of the gas are 1.03 bar, 0°C and 0.035 m^3 respectively. During the process the temperature of the gas is reduced to 243 K.
Calculate EACH of the following:

(a) The mass of the gas; (4)

(b) The final volume of the gas. (4)

Note: the Characteristic Gas Constant = 0.259 kJ/kgK = 259

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

b)

$V_1 = 0.035$ $V_2 = x$

$P_1 = 1.03 = 103,000$ $P_2 = 103,000$

$T_1 = 0 = 273$ $T_3 = 243$

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{0.035}{273} = \frac{x}{243}$$

$x = 0.031\ m^3$

a) $Pv = mRt$

$103,000 \times 0.035 = m \times 259 \times 273$

$m = 0.050985$ kg